

ADVANCES IN SEWAGE AND WASTE TREATMENT.

BY: ONTARIO WATER RESOURCES COMMISSION

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ADVANCES IN SEWAGE AND WASTE TREATMENT

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Efforts at pollution abatement in water supplies has been increasing in recent years. Construction programs have gathered momentum in Canada and in most countries. Pollution is now recognized as a national and world-wide problem. It is essential that steps be taken to make control measures effective. It is only in this way that water resources can be conserved for the many uses for which they were intended. In these programmes, involving high expenditures, critical analyses must be made of the methods utilized in waste treatment. This is necessary if the most effective results are to be assured and the most economical solution obtained.

General Objectives

An appreciation of the objectives in sewage treatment is desirable at the outset. What degree of treatment is necessary, what are the methods in use, and what are the basic principles in these methods! It is desirable to know the nature of sewage and other wastes and the effects these may have on the receiving streams or watercourses. What are

the limits to which treatment can go in removing substances found even in minute quantities! How can costs be altered through the design of the treatment works, either the capital costs or operating charges! Should industrial wastes be treated with domestic sewage in the one plant or is it preferable to keep them separate, and what is the result in each instance! These and many other questions come to the fore. What is revealed when an examination is made of the advances that have taken place in this field over the years! More important probably, will be the advances which can be expected in the future, and how the past developments have influenced these. It is obviously not feasible to discuss all details of the progress made in treatment processes. That is a very large field, but it is possible to examine some of the general principles involved in these steps forward.

In sewage treatment, as in most engineering problems, cost must always be given close attention. There are many measures which can be used if cost is not a serious factor. When something like \$50. per capita may be involved to build a sewage treatment plant of the secondary type the designer must examine closely all measures which can reduce this cost without detracting from the results he sets out to achieve. The research laboratory and the developer need to direct their

efforts at improving existing measures and developing new ones which will aim at economy. In a programme of waste disposal many branches of science can contribute. Hence there is need for a co-ordinated approach by many towards both better and simpler methods, and particularly to a reduction in costs.

What Can Treatment Works Accomplish

Sewage and waste purification works can accomplish a great deal. There are also many things they do not overcome in regular treatment. There is a good deal of flexibility in the designs used depending on what degree of processing is needed. Sewage coming from urban communities is a complex mixture chiefly because it is not merely the domestic wastes from homes and offices, but it contains a goodly portion of industrial wastes and substances from many sources. It is common to state that sanitary sewage should contain about 0.20 lbs. of suspended solids per capita and 0.17 lbs. of B.O.D. (Biochemical Oxygen Demand). This would be in order except that some systems receive much industrial wastes while others have little. Some wastes have much organic matter and a high B.O.D. figure. Others have constituents not measured in the normal tests. A variety of chemical wastes may be present, some of which may, even if in only small quantities,

travel long distances in a stream. Some are toxic, some produce obnoxious tastes, some carry oil, others may be strongly acid or alkali, while some carry floating material as feathers, garbage, or finely divided substances which do not respond readily to the usual treatment processes, and some contain much fertilizing values for plant growth.

It would be unrealistic to think that the sewage treatment plant should be designed to remove or nullify all of these substances. For one reason, the cost would be very high. The question arises as to whether industrial wastes should be treated with the municipal sewage or be dealt with separately. Some wastes readily respond to the same treatment as sewage, and a joint plant has advantages. In other cases it is preferable to consider treatment of the industrial waste separately where the specific ingredients can be attacked. There is thus no rule that will apply in all cases.

The modern sewage purification plant when designed for full treatment is an effective device. It can remove organic matter as measured by the B.O.D. test from about 300 p.p.m. to 10 p.p.m. or less. A similar reduction can be made for suspended solids. The bacterial content, measured by the coliform test, is reduced in the biological processes,

and when chlorine is applied to the effluent the reduction in coliform can be almost complete. Thus measured in these terms a sewage treatment plant accomplishes a great deal and converts a heavily laden raw sewage to a clear, odourless water with a low bacterial content. Whether the purification is to go this far will depend on local requirements. In bringing about specific results the plant is designed to fit the local conditions.

Treatment of sewage or industrial waste must be designed to safeguard the watercourse against undue pollution. The final test is not so much the quality of the effluent but the effect on the stream after initial dilution has taken place. The use made of that stream will have an important relationship to the degree of purification needed. The volume of water in the stream is a significant factor. The flow of water in the Great Lakes System gives a high dilution for any effluent, and when the water is flowing as in a river there is a continuous mixing and removal. Discharge into a lake may tend to concentrate the effluent at the end of the outfall when the water is quiescent.

Local requirements may place a heavy or a light burden on the treatment processes. The cost will be affected directly. The designer must be prepared to incorporate in the works

whatever is needed to satisfy local conditions. He can design for a degree of treatment that will permit the effluent to be discharged satisfactorily in a watercourse with little or no water at times. In the light of these stringent requirements and wide variations it is essential that every true advance be utilized and that there be a co-ordinated effort to seek out the best means and the most economical ones for this purpose.

The stream or lake receiving wastes, either raw or treated, responds to that load, natural purification processes are constantly at work, sometimes more actively than at others. The result may be that organic matter will be reduced readily by the oxygen in the water, the supply of which will be restored from the air and plant growth. Bacteria tend to die out in the water, an unnatural habitat. But other substances may travel long distances in a stream or remain active for a long period in a lake. Chemical substances may travel several hundred miles before their effects are reduced to insignificant amounts. Phenol, as a potent taste substance in water, may likewise travel great distances, and even small amounts as low as one part in a billion, may be objectionable in drinking water. Oils and many other substances have disastrous effects on the

stream. The great increase in the use of chemical substances such as synthetic detergents, pesticides, weedicides and others, may result in these being carried into the streams and their effects being felt in a variety of ways. All of these conditions emphasize the need for effective waste treatment facilities if the water resources of the nation are to be safeguarded and kept clean.

Treatment Processes in Use

The fundamental processes in sewage treatment have been utilized for many years. Important changes have been made in the application of these methods, but the principles have not changed radically. They include physical measures as in screening, sedimentation, flotation, and transportation of materials; biological processes as in sand filtration, trickling filters, activated sludge systems, sludge digestion, lagoons or stabilization ponds, and miscellaneous aerobic methods; chemical treatment as in flocculation and disinfection. These make up the main measures employed in removing the objectionable ingredients from sewage and other liquid wastes. Many modifications of these measures have been instituted and many more can be expected in an effort to assist the basic processes and thereby to shorten the treatment time, increase efficiency, and reduce costs. These advances made over the years are important in

meeting the objectives for clean streams and conservation of our national water resources.

The treatment of sewage and industrial wastes readily separates into two parts, one the treatment of the liquid to discharge an innocuous effluent, the other to dispose of the solids or sludge removed in the process. The two are separate and distinct. Each has its own problems to be overcome. Each is attacked by research and studies continuously in progress.

It may be noted that these advances, now in progress or expected in the future, should not delay the initiation of works any more than the hope for new developments in motor cars, T.V., and so many other products should postpone purchases. Public reaction, particularly where there is a desire to delay expenditures, is to wait for new developments. Another extreme view is to assume that advances are not taking place and new measures should not be accepted. Neither of these attitudes favours the cause of sewage treatment. The engineer must choose what may be regarded as a middle course. He must be prepared to design a plant now which will give the desired results. He should incorporate in his design new advances which offer a reasonable chance for success. He cannot risk his professional reputation and gamble with his client's money by specifying

something which is not proven. This decision is no easy task, especially when he is confronted with many so-called advances aimed at economy and efficiency. These processes have been numerous in the past, but the mortality rate among them has been high either because they were not proven or other advances made them of less value. Some measures have been quite successful under certain conditions, but not acceptable for others. It thus becomes an important responsibility for the engineer to serve his client effectively by choosing methods and facilities which are modern and economical but not before these have been tried enough to offer an opportunity for success. The earlier methods, in most respects, were capable of producing a good effluent and in obtaining the necessary results, but the means for doing this and the cost are considerations which must be examined critically at all times.

What Are The Advances?

A review of some of the more significant advances in sewage and waste treatment of the past can aid in assessing what is important now or what the trend may be in the future. It is not feasible to describe in detail these various steps, but certain general principles may be sufficient for the purpose. They can be considered under the broad headings of physical

processes, biological treatment, and chemical treatment.

The Physical Processes

Physical processes have been used widely in sewage purification. They remove solids by screening, sedimentation, or flotation. They involve the transportation of the liquids and sludge from place to place and provide other useful work about the plant. They are inter-related to the biological processes, and the two work jointly to attain the same objective. Physical processes are usually cheaper than biological measures. Primary or partial treatment is nearly all due to physical forces.

The opportunity for improvement in physical processes is attested to by the great changes made over a period of years. Mechanization of these methods has greatly changed the operation of sewage works. This process thus keeps pace with similar trends in other fields. While these improvements may not change the quality of the plant effluent to any great degree they accomplish much easier operation and greater convenience.

Some of the improvements which have taken place from earlier days are seen in the mechanical cleaning of screens, thereby permitting smaller openings, the more widespread use of

fine screens, grinding of screenings for return to the sewage and consequent ease of handling, mechanical removal of settled grit and the washing of organic material from grit, the use of mechanically cleaned sedimentation tanks for primary treatment and in conjunction with secondary treatment, all aimed at improved convenience and ease of operation.

Important advances to date in the physical processes have resulted in the widespread application of improved settling efficiencies in mechanically cleaned tanks, and in ways to remove the settled sludge continuously and with little inconvenience. Much has been done to provide better and more correctly spaced overflow weirs, and improved inlet and outlet arrangements for the tanks. Studies have been made on the effects of these on tank performance with the result that the designer has information to enable the best arrangement for these tanks. It can be considered that in sedimentation performance the advances have been directed to improved efficiency in solids removal and convenience of operation. Further efforts in this same general direction can be expected. Most settling tanks are now mechanically equipped, and they provide good results.

Flotation as a physical process acts in the reverse to sedimentation, and the solids are floated to the surface entrained in air bubbles. While this is not widely used in

sewage treatment it has promising results in certain industrial wastes. The opportunity for removing the solids in this fashion offers efficiency and economy. This is an advance of recent years, and more efforts can be expected in this.

Grit removal involves careful design of the units as well as effective measures for moving this material from the tanks. Various ways can be used. A further action is the washing of the grit free of organic material. Progress has been made in this with the result that the final product can be deposited almost anywhere without fear of odours or offensive conditions. Much of the advance made in this part of sewage treatment has to do with transportation and washing for convenient and economical disposal.

The Biological Processes

Sewage purification has always relied on biological processes for secondary or full treatment. They are subject to all the vagaries of bacterial action. So long as this condition prevails the efforts to bring improvements will be directed to assisting these natural agencies, by creating environments in which the processes can proceed rapidly. The steady progress through such methods as sand filtration contact filters, trickling filters, activated sludge, oxidation ponds,

and other aerobic methods attest to the efforts made to reach this objective. Rapid oxidation with high purification at minimum cost has been the search over the years. Great improvements have been made, but only general principles can be reviewed at this time.

Most recent advances have involved trickling filters, the activated sludge process, and modifications of these methods. In the former the big improvement was the transition from low-rate to high-rate treatment through the creation of a favourable environment for biological activity. In doing so the capacity of the filter was greatly increased. The activated sludge process has been subjected to an immense amount of study and research. Continuous improvements have been found, but what further advances can be anticipated is not readily apparent. The objectives have been the same as for the trickling filter studies. The process now can be relied on to produce an effluent with low organic and solids contents. Control measures have been found to offset difficult constituents in the sewage and to ensure good results under many different conditions.

A number of modifications have been developed for the basic process of activated sludge. All are intended to speed up the process, ensure good results, and lower the costs.

These alterations are likely to continue. The engineer must carefully examine these processes for his particular project. He must satisfy himself that the method is sufficiently proven, and that it is better than others for his purpose.

Automation

Automation has been used in ever increasing ways in sewage treatment. This has offered a wide scope for the engineer and manufacturer. It promises better control of the essential processes and removal of the weakness of the personal element. Automation goes hand in hand with mechanization, and it can be expected that further advances will be made in this direction.

Sludge Disposal

After treatment of the sewage or waste there remains the difficult problem of disposal of the solids or sludge. This has grown to be a major feature of the overall requirements of reducing these residues to something which no longer is dangerous or offensive. Sludge disposal has gone through many changes and the end is not in sight. The efforts of many have been concentrated on this solution.

Sludge being largely organic and subject to decomposition can produce highly offensive odours. The objective is therefore to prevent the escape of odours while

at the same time enable the rapid break down of organic material at a minimum of cost. The final product must be disposable by piling or put to a useful purpose.

Sludge digestion, so widely used for many years, was a development of the anaerobic process at work in the early septic tanks. Steps were taken to provide the maximum adjustment of the biological environment such as heat and foods. Considerable cost is involved in sludge digestion and in dewatering the resulting solids. The break down of organics in digestion is relatively slow. The efforts at improvement have been concentrated at speeding up the process or by-passing this for other measures, and in reducing costs both in capital and operating.

Sludge disposal is still a real problem not so much in attaining a satisfactory end product but improving efficiency and economy. Omission of the digestion process can eliminate the capital costs for these tanks. It is necessary to balance this improvement against the condition of the final product and the annual overall savings.

Dewatering of sludge has been an outstanding difficulty. Open sludge drying beds can result in slow drying, odours and higher labour costs. They are not favoured now. Vacuum filters for dewatering of either digested or raw sludge have

gone through many changes. They call for conditioning of the sludge with chemicals, and the control of costs is an important element.

At present a number of other methods for sludge disposal are receiving attention. The dewatering of raw sludge on vacuum filters with sufficient chemicals to prevent odour problems is one approach used in a number of works. Another method employs a rotating filter made of nylon fabric and not requiring chemical conditioning. Still another aims at removal of the water content by sonic or high frequency vibrations. No chemicals are involved.

A recent development in Canada, the atomized suspension technique, embodies different principles. The raw sludge is thickened to about 10 to 12 per cent solids and then sprayed through a nozzle into a chamber heated by electricity or gas. The sludge can be dried or burned at a high enough temperature to avoid odours. One plant is in operation at Beaconsfield, P.Q.

Sludge incineration has been used for many years with satisfactory results. Improvements have been consistent in this method.

The newer or modified methods for sludge disposal must be considered in respect to accomplishment of objectives, and assurance of trouble free operation at competitive costs. Any new process requires a period of trial under different conditions to overcome possible defects and to determine costs. It can be expected that the search for the ideal sludge disposal process will continue and that further advances will follow.

Disinfection and Polishing Effluents

Sewage effluents must be discharged sometimes under stringent conditions such as low diluting water, proximity to water intakes or bathing beaches. Further improvements in the effluent may then be necessary. Efforts have been made to polish the liquid by the use of sand filters, and more recently by the use of micro strainers. Improvements are possible in these ways.

Disinfection of effluents is increasing after the practice established in water treatment. In this way the bacterial content can be greatly reduced and other benefits derived. As the trend towards better effluents moves along more use can be expected of disinfecting processes.

Single vs. Multiple Plants

Another advance in sewage treatment has been obtained

by using larger plants rather than a number of small ones. This involves no new or different process but rather an opportunity for operating efficiency and lower costs. A small plant can, if properly designed, produce an effluent equal to that of the large unit, but it may not receive the same supervision given at a large plant where trained and capable operators are in charge.

Industrial Processes

Industrial waste treatment processes are numerous. The advances made in these have kept pace with the progress in sewage treatment. Discussion of all these is not feasible. Some of the methods are the same as for sewage, while others depart widely. The changing composition of industrial wastes calls for the development of appropriate measures to meet each new situation.

Summary and Conclusions

Sewage and waste purification has been subjected to many developments, all leading to the objective of high efficiency, well purified effluents, and low cost. Physical processes, biological treatment, and disinfection have all moved steadily forward towards the desired goal. In spite of the improvements made there is still much more that can be

expected. The need for treatment of sewage and industrial wastes is aggravated by concentration of population in urban centres and by industrial expansion with its great variety of complex wastes. Concentrated research and study of different methods will be needed. The designer of treatment facilities should have available methods which can be used with confidence to attain the desired results under many different circumstances.



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